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Description

COUNTERING CREDENTIALS COPYING

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Related Application This patent application is related to and claims priority from U.S. provisional patent application serial no. 60/226,429 filed on August 18, 2000, entitled "Countering Credentials Theft", having the same inventor and assignee as the present patent application.

Technical Field This invention pertains to the field of authenticated communications between and among digital devices such as computers, and, specifically, pertains to techniques for thwarting the copying of credentials by nefarious persons or otherwise.

Background Art

Diffie-Hellman key exchange, as described in U.S. patent 4,200,770, is a mechanism to permit two entities to have a shared secret; the secret could be an encryption key. In the present invention, shared unpredictable secret 50 is not an encryption key.

Disclosure of Invention

The present invention comprises systems, methods, and computer readable media for authenticating a client device (1) to a server device (5). A preferred method comprises the

1 steps of generating a shared unpredictable secret (50),
2 storing the shared unpredictable secret (50) in the client
3 device (1) and in the server device (5), and requiring the
4 client device (1) to prove that it contains the correct shared
5 unpredictable secret (50) as a precondition to the server
6 device (5) validating the client device (1). The shared
7 unpredictable secret (50) is replaced by a new shared
8 unpredictable secret (54) each time the server device (5)
9 validates the client device (1).
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11

12 **Brief Description of the Drawings**

13 These and other more detailed and specific objects and
14 features of the present invention are more fully disclosed in
15 the following specification, reference being had to the
16 accompanying drawings, in which:

17 Figure 1 is a block system-level diagram of a preferred
18 embodiment of the present invention.

19 Figure 2 is a flow diagram of a preferred embodiment of
20 the registration/reset phase of the present invention.
21

22 Figure 3 is a flow diagram of a preferred embodiment of
23 the log-in phase of the present invention.

24 Figure 4 is a flow diagram illustrating an alternative
25 embodiment of the method illustrated in Figure 3.

26 Figure 5 is an illustration of shared unpredictable
27 secret 50 and its progeny.
28

Detailed Description of the Preferred Embodiments

As used in the present patent application, client (sometimes referred to as "client device") 1 can be any digital device, e.g., a personal computer, mobile phone, smartcard, Internet appliance, or any other network accessible device. There may be one client 1 or, as illustrated in Figure 1, a finite number n of clients 1. Each client 1 wishes to communicate with an infrastructural component that is referred to in the present patent application as a server (or "server device") 5. Server 5 may provide any type of service to client 1. For example, server 5 might be an Internet service provider or a telephone network access point. The communications link between client 1 and server 5 may be any link, such as a wireless link, a wired link, or a link over a network 4, which may be an open network such as the Internet. The process that commences with client 1 requesting validation with server 5 and including server 5 checking proof data that client 1 has generated from the shared unpredictable secret 50 is referred to herein as a "log-in". A log-in results in client 1 being either validated or not validated by server 5.

One concern in such an environment pertains to credentials sharing. In this scenario, a person who has

1 access to a client device 1 voluntarily shares his personal
2 credentials, such as a password or private cryptographic key,
3 with other user devices 2. All of these user devices 2 employ
4 the user account of the original user. Two problems that
5 arise from this scenario are: 1) It is difficult for server 5
6 to hold particular users 2 accountable for their actions when
7 using the services provided by server 5, since some or all
8 users 2 are indistinguishable from each other; and 2) Users
9 may fraudulently avoid paying subscription fees that are
10 designed for payment on a per-user basis.

13 Another concern is outright credentials theft. In this
14 scenario, a nefarious person having access to a client-like
15 device, referred to as "attacker 3" in Figure 1, penetrates a
16 legitimate client device 1, copies stored credentials data
17 from client device 1 into attacker device 3, perhaps
18 supplements this thievery with a determination of other
19 information such as the user's password, personal
20 identification number, or social security number from other
21 sources, and then masquerades as the legitimate user from the
22 attacker device 3. When the client device 1 being attacked is
23 a hardware device and not a software module, this scenario is
24 sometimes referred to as "device cloning". Client devices 1
25 that are typically cloned include mobile telephones and
26 smartcards.
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1 The present invention also applies to the copying of a
2 portable credentials storage medium such as a magnetic stripe
3 card or ticket if that medium is writable as well as readable
4 by the terminal device in which it is used. In this case, the
5 term client device 1 is taken to mean the combination of the
6 portable credentials storage medium and the terminal device in
7 which it is currently inserted.
8

9 The present invention uses a method of stateful
10 authenticators to provide a low cost, low overhead means of
11 detecting when one user account is being employed for more
12 than one client device 1 over a period of time. Specifically,
13 the stateful authenticator used herein is a shared
14 unpredictable secret 50. The present invention has utility in
15 countering credentials sharing behavior by effectively
16 restricting use of a user account to one or a limited number
17 of client devices 1. The invention also counters credentials
18 theft by means of detecting the use of one user account from
19 more than one client device 1 after stored credentials have
20 been copied between client devices 1, regardless of how easy
21 or difficult it was to copy the credentials from the original
22 device 1.
23
24

25 All of the method steps illustrated herein describe
26 modules that can be implemented in hardware, software, and/or
27 firmware. Some of these modules reside on the client device 1
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1 and some on the server device 5, as will be readily understood
2 by examining the Figures in conjunction with the following
3 description.
4

5 The method will first be described with respect to a
6 special case in which there is but one legitimate client
7 device 1. There are two phases of the method of the present
8 invention: a registration/reset phase and a log-in phase.

9 Figure 2 illustrates the registration/reset phase. In
10 step 21, client 1 typically presents a user's authentication
11 data to server 5. The ensuing dialog between client 1 and
12 server 5 is geared to determining whether the user associated
13 with client 1 is legitimately associated with a claimed user
14 account. The authentication data presented by client 1 may
15 include private personal data, a response to a pre-established
16 challenge question posed by server 5, a biometric input such
17 as a fingerprint or an eyeball scan, etc. Alternatively, the
18 registration/reset phase may involve the user making a
19 payment, in which case authentication data may or may not need
20 to be presented by client 1 to server 5. The payment can be
21 made by client 1 securely crediting server 5's account, and
22 can be made online or offline. The registration/reset phase
23 is typically undertaken less frequently than the log-in phase.
24
25

26 At step 22, server 5 decides whether the authentication
27 data presented by client 1 are acceptable. If not, client 1
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1 is not allowed to register (step 26). If acceptable, client 1
2 is allowed to register (step 23). In this eventuality, the
3 shared unpredictable secret 50 is generated (step 24).
4

5 As illustrated in Figure 5, the shared unpredictable
6 secret (SUS) 50 comprises an unpredictable component 51 and an
7 optional fixed component 52. Unpredictable component 51 may
8 be generated by a random number generator or a pseudo-random
9 number generator. Typically, unpredictable component 51 is
10 generated at server 5 and communicated to client 1, but it may
11 also be generated at client 1, or at a combination of server 5
12 and client 1. As an alternative to communicating
13 unpredictable component 51 to client 1, unpredictable
14 component 51 may be pre-installed in client device 1 during
15 manufacture or during a device 1 personalization process.
16

17 When used, fixed component 52 typically comprises
18 identification information. For example, fixed component 52
19 may be a serial number of the client device 1. This could be
20 useful when there are two or more client devices 1 associated
21 with the same user account number. Conversely, fixed
22 component 52 could be the user account number when there is
23 more than one user account number associated with the same
24 client device 1. This situation may occur, for example, when
25 a user has one account number for business use and another
26 account number for personal use; or when two users share the
27
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1 same cellular telephone 1; or when the client device 1 is a
2 terminal into which users insert their credentials storage
3 media.
4

5 Typically, after server 5 has generated SUS 50, server 5
6 transmits SUS 50 to client 1. The transmission is preferably
7 encrypted, for reasons of security. Any type of encryption,
8 including symmetric or asymmetric encryption, may be used.
9 Alternatively, an SUS 50 having an unpredictable component 51
10 is generated by the aforementioned Diffie-Hellman key exchange
11 technique, or pre-installed in device 1 as described
12 previously. The same SUS 50 is stored in both server 5 and
13 client 1 (step 25). SUS's 50 may be stored in a secure
14 fashion, such as using tamper-resistant hardware protection,
15 e.g., epoxied integrated circuits, or by means of dynamically
16 changing the location of SUS's 50 (and new SUS's 54) in
17 storage.
18

19 Figure 3 illustrates the basic method of the log-in
20 phase. The log-in, at least for legitimate users, is not
21 meant to be attempted until after the registration/reset phase
22 has successfully concluded. Steps 30, 31, and 32 are
23 optional. At step 30, client 1 presents credentials to server
24 5. The credentials may include a password, personal
25 identification number (PIN), a transformed (e.g. hashed)
26 password, biometric signature, portable credentials medium
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1 identifier, or cryptographic authentication proof generated
2 from a private cryptographic key. Since log-ins normally
3 occur more frequently than registration/resets, the character
4 and content of the credentials and procedure are such that the
5 server's check of the credentials is typically simpler and
6 faster than the server's check of the user's authentication
7 data in previously-described step 21. In step 31, server 5
8 checks the credentials. If the check fails, typically the
9 client is not validated (step 32).

10
11 If step 32 is entered, one or more things may happen.
12 For example, client 1 may be totally rejected and not allowed
13 to be validated ever again. Less onerously, client 1 could be
14 given reduced privileges, such as the ability to read a Web
15 page stored on server 5 but not to conduct any financial
16 transactions thereon; or client 1 could be made to re-enter
17 the registration/reset phase.

18
19 If the check passes, the method moves to step 33, where
20 client 1 presents proof data to server 5. The proof data
21 allows server 5 to verify that client 1 holds a correct secret
22 50, 54. (Normally, the secret is SUS 50. However, the secret
23 could be new SUS 54, in the case where the log-in is a
24 subsequent log-in following the re-set of server 5 as
25 described in conjunction with step 43, below. For purposes of
26 simplifying this discussion, it will be assumed that the proof
27
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1 data are computed upon SUS 50.) It is desirable that SUS 50
2 itself be not directly communicated over an open network 4
3 lest it be intercepted by a nefarious person. One method by
4 which client 1 computes proof data without revealing SUS 50
5 itself is for client 1 to compute a one-way function of SUS
6 50. The one-way function is typically a cryptographic hash
7 function. Then, at step 34, server 5 checks the proof data by
8 applying its (server 5's) proof data generation algorithm to
9 its (server 5's) stored version of SUS 50. If the proof data
10 generated by server 5 matches the proof data presented by
11 client 1, client 1 has passed the test, and the method
12 proceeds to step 37. Otherwise, client 1 has failed the test
13 and is not validated at step 32. Step 32 operates as
14 previously described.

15
16 In order for this method to work, client 1 and server 5
17 have to be using consistent if not identical proof data
18 generation algorithms. It is immaterial whether or not an
19 eavesdropper knows what this algorithm is (or what these
20 algorithms are).

21
22 At step 37, update data 53 and a new shared unpredictable
23 secret 54 are generated, typically by sever 5. On Fig. 3
24 (boxes 37 and 39), item 54 is referred to as a "secret" rather
25 than a "shared unpredictable secret", because the contents of
26 the storage area that server 5 uses for SUS's are not replaced
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28

1 with new SUS 54 until step 40 is executed, below. Thus, the
2 secret is not yet "shared".
3

4 Then, at step 38, server 5 sends update data 53 to client
5 1. Update data 53 is such that client 1 and server 5 are able
6 to generate new SUS 54 from the most recent version of SUS 50,
7 by means of applying update data 53 thereto. Typically, the
8 step of applying update data 53 to SUS 50 comprises computing
9 a one-way function of the combination of SUS 50 and update
10 data 53. For example, update data 53 could be a new random or
11 pseudo-random number that client 1 and server 5 XOR with old
12 SUS 50 in order to generate new SUS 54. Alternative to the
13 use of update data 53, server 5 could send an encrypted new
14 SUS 54 to client 1, but the advantage of sending update data
15 53 is that update data 53 do not have to be encrypted, thus
16 making for a simpler and less cumbersome protocol. In an
17 alternative embodiment, in situations where the optional
18 acknowledgement data are used (see below), server 5 sends to
19 client 1 an old SUS 50 that hasn't been acknowledged yet.
20
21

22 At step 39, client 1 updates its (client 1's) storage
23 area that is allocated to SUS's with new secret 54. Client 1's
24 storage area may be on a portable credentials storage medium.

25 Steps 41, 42, and 43 are optional. Without these steps,
26 the method illustrated in Figure 3 works well when the
27 communications channel 4 is clean and uncorrupted, but a
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1
2 potential problem arises in the case of a noisy or corrupted
3 channel 4: update data 53 could be lost in transit between
4 client 5 and server 1, or client 1 could fail to correctly
5 store new secret 54.

6 The inclusion of steps 41, 42, and 43 resolves the
7 problem of noisy or corrupted channels 4 or a malfunctioning
8 client device 1, through the use of acknowledgement (ACK)
9 data. In step 41, client 1 sends the ACK to server 5 after
10 client 1 has successfully received update data 53 and stored
11 the new secret 54. The ACK may optionally contain proof data
12 allowing server 5 to verify that client 1 has successfully
13 computed the new SUS 54. The proof data should not be the
14 same proof data as used in step 33; otherwise, a replay attack
15 would be possible.
16

17 At step 43, server 5 is set (e.g., programmed) to accept
18 proof data emanating from any SUS's since the previous
19 validation, plus new SUS 54. Another way of saying this is
20 that server 5 is adapted to accept from client 1 any proof
21 data that are generated from a secret that is newer than the
22 secret for which the most recent acknowledgement data have
23 been received by server 5. Thus, if the situation is that
24 client 1 has received the update data 53, but for some reason
25 the ACK has been lost in transit, during the next log-in,
26 client 1 at step 33 will be presenting proof data emanating
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1 from new SUS 54, and server 5 at step 34 will be programmed to
2 accept said data. If, on the other hand, update data 53 were
3 not received by client 1, then, during the next log-in, client
4 1 at step 33 will be presenting proof data emanating from an
5 old SUS 50, and server 5 at step 34 will be programmed to
6 accept said data.
7

8 Step 42 illustrates the reality that server 5 may or may
9 not receive the ACK, either because the update data 53 were
10 lost in transit, the ACK was lost in transit, or the client
11 device 1 failed. If server 5 receives the ACK within a
12 preselected "time-out" period, then client 1 is validated at
13 step 44 and step 40 is entered into. At step 40, server 5
14 updates its (server 5's) storage area that is allocated to
15 SUS's with new secret 54. Thus, new secret 54 becomes a new
16 shared unpredictable secret, because it is now shared by
17 client 1 and server 5. As a substep to step 40, server 5
18 deletes SUS 50 and any older SUS's from its list of acceptable
19 SUS's. Thus, in future log-in attempts, both client 1 and
20 server 5 will have stored therewithin new SUS 54; and the
21 proof data (of client 1 in step 33 and server 5 in step 34)
22 will be based upon new SUS 54.
23
24

25 If, on the other hand, server 5 does not receive at step
26 42 the ACK from client 1 during the time-out period, client 1
27
28

1 is not validated at step 32, which executes as described
2 previously.
3

4 The protocols described herein have the following
5 desirable properties: 1) Any SUS (50) value produces no more
6 than one validation; and 2) If the protocol fails at any
7 stage, both client 1 and server 5 are left in a state that a
8 new invocation of the protocol will operate correctly.
9

10 Optionally, for example in conjunction with step 34,
11 server 5 maintains an audit trail of log-in attempts, noting
12 in particular those log-in attempts in which the step 34
13 checks have failed. Each audit record should contain the
14 then-current values of old SUS 50 and new SUS 54. In the
15 event a legitimate user disputes accountability for actions
16 attributed to use of his account, if server 5 maintains an
17 audit trail of log-in attempts, the service provider or
18 systems administrator can use the audit trail in resolving
19 such disputes.
20

21 By using the techniques described herein, any user
22 possessing or knowing correct credentials and attempting a
23 log-in from a client device 1 that holds the correct SUS 50
24 will succeed in being validated, even in the event a log-in
25 sequence is not successfully completed, owing, for example, to
26 a communication or system failure.
27
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1 The present invention automatically protects against
2 message replay, i.e., the situation where an eavesdropper
3 records a session and plays it back. This is because a new
4 SUS 54 is generated at each successful validation.
5

6 If the legitimate user of the credentials voluntarily
7 shares his credentials with one or more other users who will
8 be operating from what in essence becomes an illegitimate
9 client device 2, only one client (legitimate client 1 or
10 illegitimate client 2) can successfully log in subsequently
11 without server 5 invoking special action, such as causing the
12 requesting client 1,2 to re-execute the registration/reset
13 phase. This represents a disincentive for the legitimate user
14 to share his credentials, since his own usage of his account
15 will be negatively impacted.
16

17 If the legitimate user's credentials are copied in a
18 credentials theft, then one of the following scenarios will
19 subsequently occur:
20

21 1) The legitimate client 1 logs in again before the
22 attacker 3 attempts to masquerade as a legitimate user. In
23 this case, the attacker 3 log-in will be alerted to the server
24 5 and consequently be subject to special action, such as
25 rejection outright or granting of reduced privileges.

26 2) The attacker 3 logs in before legitimate client 1
27 logs-in again. In this case, attacker 3 can successfully
28

1 masquerade as a legitimate user up to the time of the
2 legitimate user's next log-in. On the legitimate user's next
3 log-in, server 5 will be alerted and special action taken.
4 This special action might include out-of-band communication
5 with the legitimate user, investigation of the situation, and
6 consequent shut-out of attacker 3 from further validations.
7

8 An alternative embodiment is illustrated in Figure 4.
9 The method of claim 4 is identical to the method of Figure 3
10 wherein acknowledgement data are used, except that steps 33
11 and 34 are consolidated into steps 41 and 42. Thus, in the
12 Figure 4 embodiment, unlike the Figure 3 embodiment, the
13 presentation of proof data by client 1 and the checking of the
14 proof data by server 5 are not performed prior to server 5
15 generating update data 53 and new secret 54 in step 37.
16

17 Step 50 of Figure 4 replaces step 41 of Figure 3. In
18 step 50, client 1 sends both the proof data and the
19 acknowledgement data to server 5. The proof data are computed
20 on the new secret 54. The proof data could serve a double
21 role as proof data and acknowledgement data. In this case,
22 there is no need for acknowledgement data separate and apart
23 from the proof data.
24

25 Step 51 of Figure 4 replaces step 42 of Figure 3. In
26 step 51, server 5 checks both the proof data and the
27 acknowledgement data, or, in the case where the proof data
28

1 serve the double role as proof data and acknowledgement data,
2 the proof data.
3

4 As stated previously, there may be legitimate use of a
5 number n of different client devices 1 by a single legitimate
6 user. In this case, server 5 holds current SUS's 50 and new
7 SUS's 54 for each client device 1, and considers each client
8 device 1 to be legitimate; and each client device 1 has its
9 own unique SUS 50 and new SUS 54. The number n of clients 1
10 may be restricted in accordance with local policy. In this
11 scenario, SUS's 50, 54 are respectively unique from one device
12 1 to the next. The registration/reset process has to be
13 undertaken by each client device 1 to establish each SUS 50.
14 In all other respects, the invention is the same as described
15 above in conjunction with the single client 1 embodiment.
16

17 The above description is included to illustrate the
18 operation of the preferred embodiments and is not meant to
19 limit the scope of the invention. The scope of the invention
20 is to be limited only by the following claims. From the above
21 discussion, many variations will be apparent to one skilled in
22 the art that would yet be encompassed by the spirit and scope
23 of the present invention.
24

25 What is claimed is:
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